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G1N
Selected US specifications from IPC sub-classes
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(54) ECG telemetry system

(57) The system comprises a sensor, eg a medical sensor, which produces a first signal representing a monitored parameter, eg a standard ECG. A pulse generator (10) produces a pulse train which is modulated by the first signal. For instance pulse spacing is modulated. The mark / space ratio is low eg 1: 5 or less. An RF oscillator 11 is modulated by the modulated pulse train to produce an RF signal which is transmitted via an aerial 12. By using a low mark / space ratio low power consumption is achieved.

FIG 3

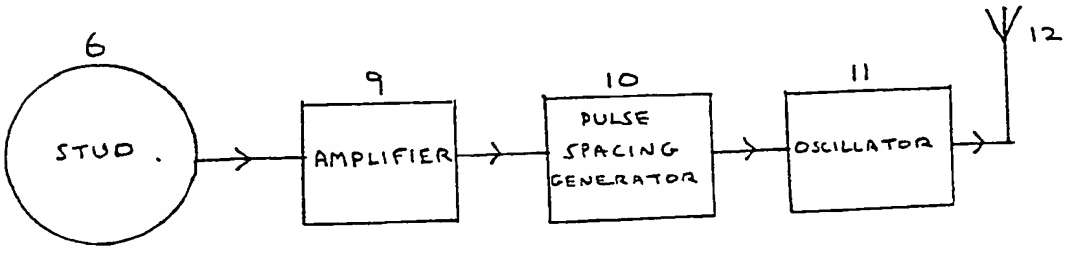

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FIG 1

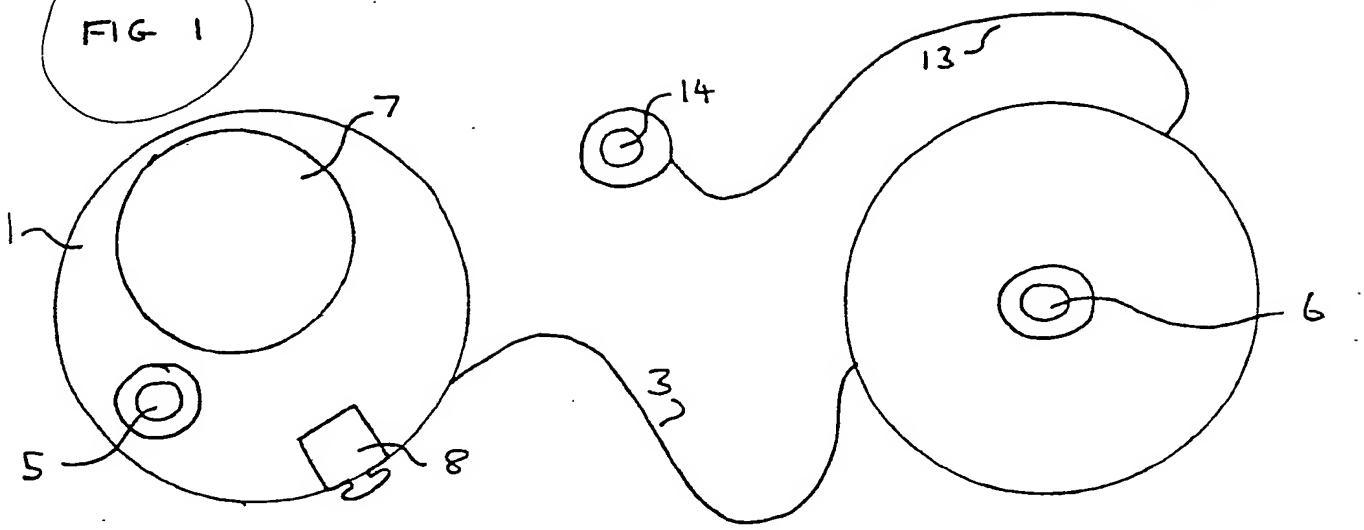

FIG 2

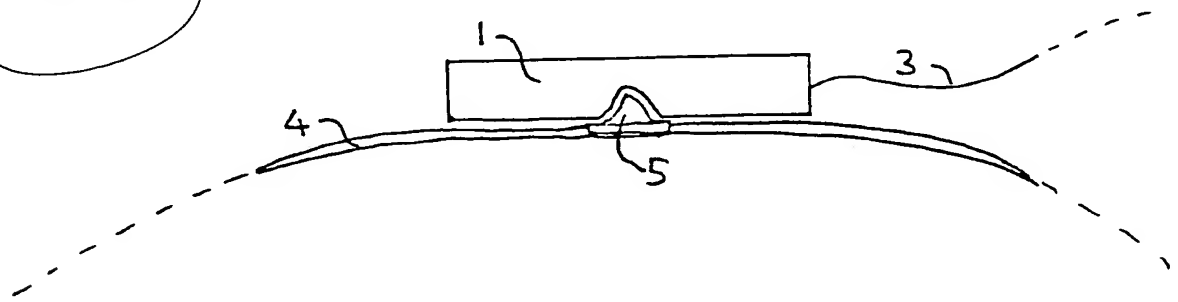

FIG 3

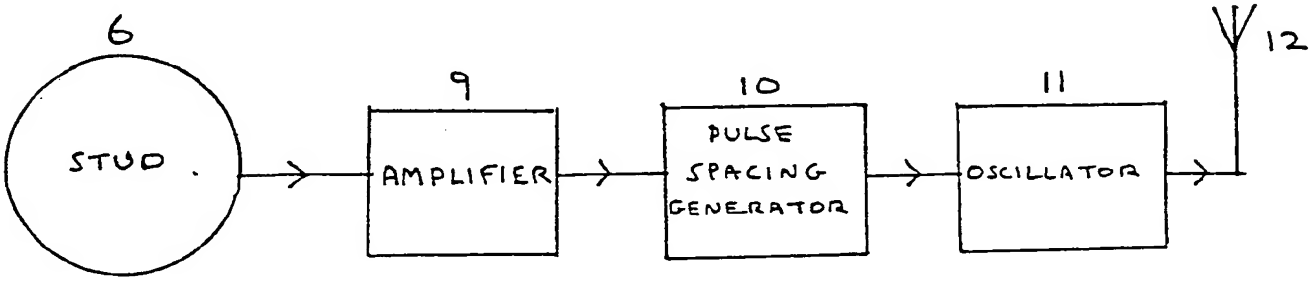

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FIG 4

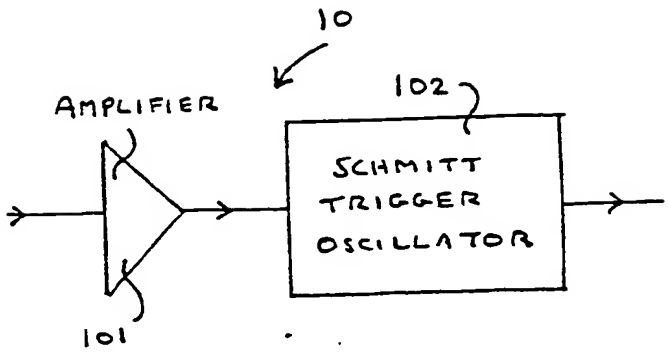
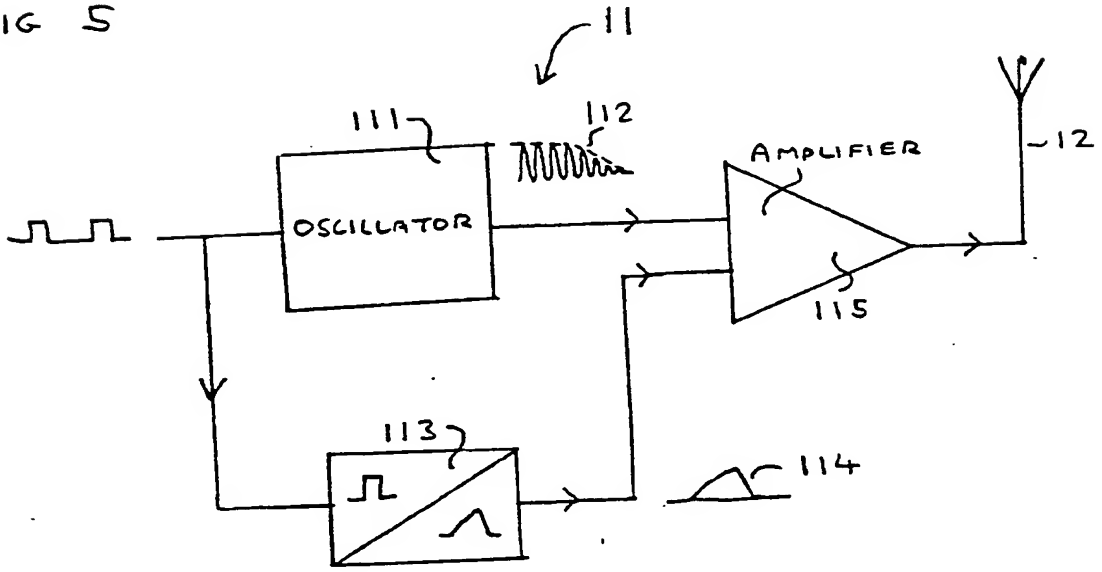


FIG 5



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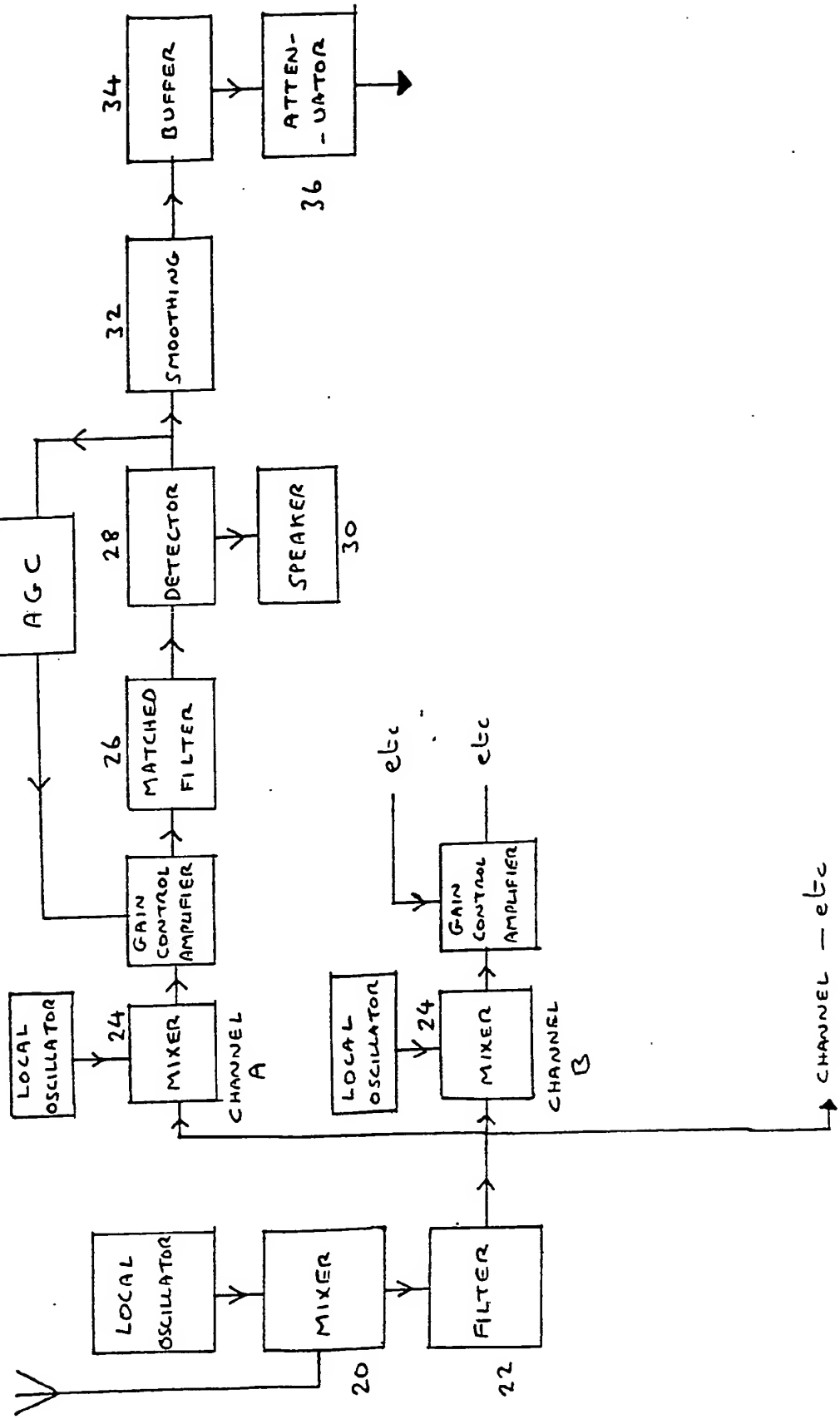

FIG 6

TELEMETRY SYSTEM

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This invention relates to the transmission without connection by wire, of varying parameters, in particular those arising in patient monitoring situations, such as the ECG, temperature or other parameters.

Current devices suffer from one or more of the following disadvantages;

1) The presence of wires connected from the equip--ment to the patient, which can result in unwant--ed interference or lead effects.

2) Relatively high power consumption for continuous monitoring.

3) Relatively large physical dimensions hindering the wearer.

The present invention aims to substantially improve on the above limitations.

According to the present invention, there is provided a transmission apparatus for a telemetry system, compris--ing means to form a first signal representative of a parameter to be monitored and means to form a pulsed radio frequency signal modulated by the first signal, the mark to space ratio of the pulsed signal being low, preferably 1:5 or less, more preferably 1:10 or less, and more preferably 1:20 or less.

Since the individual pulse duration is short compared with the intervening gaps, the power consumption is considerably less than would be obtained by continuous transmission.

The output from one or more transmitters are sent to a receiver or receivers, capable of identifying and distinguishing the pulses from each transmitter simultaneously.

In the case where the apparatus is to form a part of a biotelemetry system, a sensing means for monitoring body parameters is made of unitary construction with the means by which the output of the sensing means is processed and transmitted and with the power supply, such as a battery. The sensing means may comprise more than one portion, with the other integers being of unitary construction with and shared amongst the various portions of the sensing means.

There follows a description by way of example of specific embodiments of the present invention, reference being made to the accompanying drawings, in which;

Figure 1 is a schematic diagram of a transmission apparatus;

Figure 2 is a schematic side view of part of the apparatus;

Figure 3 is a schematic block diagram of the circuitry of the apparatus;

Figure 4 is a schematic block diagram of the pulse spacing generator of Figure 3;

Figure 5 is a schematic block diagram of one example of the oscillator of Figure 3; and

Figure 6 is a schematic block diagram of the circuitry of a complementary receiving apparatus.

In one embodiment the system is intended for use in ECG monitoring. The transmitter consists of two compartments 1,2 joined by a connecting lead 3. These compartments are typically 30mm in diameter by 5mm thick. These com-
-partments clip directly on to standard ECG electrodes 4 by means of stud contacts 5,6. One of the compartments 1 contains a battery 7 typically of 3 volts and a swit-
-ch8. Alternatively, the switch can be omitted and instead the battery lead 3 provided with a plug which fits into a socket which for instance is on the trans-
-mitter. The other compartment 2 contains the transmit-
-ter and associated amplifiers.

The ECG signal from the electrodes 4 is fed via the stud 5,6 into a low current amplifier 9 consuming typ-
-ically about 5 micro-amps. The signal then modulates the switching threshold of an oscillator in a pulse spacing generator, eg a Schmitt trigger oscillator. The pulse generator may comprise an amplifier 1C1 which amplifies the signal from amplifier 9 and a Schmitt trigger oscillator 102. The pulse spacing generator may be stabilised by means of a self regul-
-ating mechanism. This mechanism may consist of an appropriately selected resistor supplying current, and smoothing capacitor, in conjunction with the curr-
-ent consumption characteristics of the pulse spacing generator 10. The effect is that of a constant current source feeding a zener diode. This results in a very frequency stable operation a low voltage, typically 1.7

volts, and, low current, typically 15 micro-amps, main-
-tained during falling battery voltage.
The generator 10 produces a series of space modulated
pulses of short duration, typically about 0.3 millisec-
-onds, and low mark to space ratio, typically 1:20.
These pulses control the output of a radio frequency
crystal controlled oscillator 11 working at VHF,UHF,
or micro-wave frequencies, eg around 173 MHz or 458 MHz,
depending on local standards. This contributes to the
very low overall current consumption, typically 100 to
200 micro-amps for a pulse power of 1 to 10 milliwatts.
The signal is fed to an aerial 12 which consists of a
wire 13 which is connected to a third standard ECG elec-
-rode by means of another stud contact 14. Use is made
of the ground effect of the body and capacitive loading
to improve transmitted power.
An example of the oscillator 11 is shown in Figure 5.
Each pulse of the mark to space ratio modulated pulse
train triggers an oscillator 111, producing an osc-
-illation 112 having a fast rise time and a slow decay
time. The pulse is also fed to a converter 113 which
produces an approximately triangular pulse 114 having
a slow rise time and a faster decay time. The triang-
-ular pulse biasses an amplifier 115 which also recei-
-ves the oscillation 112, which thus produces at its
output the oscillation riding on the bias. The resul-
-tant waveform transmitted by the aerial 12 has less
bandwidth than a transmitted square pulse. Also better

advantage can be made of matched filtering in the rec-
-eiver. The oscillator 111 is turned on before the amp-
-lifier 115 thus reducing the generation of unwanted
harmonics in the transmitted signal, because the start
up and decay oscillations are not transmitted. In add-
-ition the triangular waveform which is transmitted may
enhance the signal to noise ratio at the receiver.
The receiver employs a standard VHF or UHF or micro-
-wave to IF (Intermediate frequency) at 21.4 MHz mixer
20. There follows a filter 22 which passes expected
frequencies within the allowed bandwidth, but eliminates
undesired interfering signals. The incoming signals from
one or more transmitters are separated by a second tun-
-able mixing device 24, one for each channel, that prod-
-uces signals at 455KHz. Each signal then passes through
a matched filter 26 and a detector 28 producing a train
of pulses. A monitor loudspeaker 30 can be used at this
stage to tune and monitor interference. The received
train of pulses is converted into a step wave-form
which is smoothed back by a smoothing circuit 32 into
the original ECG wave-form. The output is buffered by
a buffer circuit 34 and an inverted signal is produced
which is fed via an attenuator 36 to drive the leads
to a standard ECG display monitor. In the event of the
loss of single pulses from one or more transmitters
due to outside interference or other causes, the emerg-
-ing waveform is unaffected because pulses outside ex-
-pected spacing limits are not registered. Should a

number of consecutive pulses be lost either through interference or transmitter failure then a low frequency triangular wave, typically of 1 Hz, is produced and displayed by the monitor. This system distinguishes between system failure and cardiac failure.

In another embodiment the aerial wire 13 may be incorp-orated in the lead 3 by driving this lead at radio frequency. Alternatively both leads 3,13 may be driven at radio frequency.

In a further embodiment the two compartments 1 and 2 have built-in ECG electrodes possibly utilising a flex-ible construction.

If preferred the electrodes and the transmitter assembly with the battery may be incorporated in a single flexible container.

In a further embodiment for breathing information the transmitter incorporates a piezo-electric sensor attached rigidly to the slightly flexible lid of the transmitter, also containing the battery, which is held gently against the patient's abdomen by means of a simple elasticated belt or by means of adhesive strip or strips. The output of the piezo-electric sensor is fed into the transmitter as previously described. As before the original breathing wave-form can be reconstructed by the receiver for app-ropriate display.

In another embodiment other sensors are used in conjun-ction with the same transmission technology. These sensors could be;

1) A temperature probe.

2) A pressure probe.

3) An inflated mattress producing a pressure variation in response to the patient's move-
-ments.

4) Other medical sensors.

The outputs from all these sensors can be converted into varying electrical signals using standard known technologies. The resulting signals are then suitable for transmission using the aforementioned technology. In a further embodiment slowly varying parameters such as temperature, pressure, or breathing information can be transmitted simultaneously with the ECG, by modulat-
-ing the height or width of the pulses. This information can be separated by the receiver unit and displayed. In a further embodiment the received decoded signals whether ECG or other medical parameters, can be displ-
-ayed in alternative ways;

1) The complete varying parameter can be displayed on a light-emitting diode bargraph display.

2) For every heart-beat or breath a light-emitting diode flashes once.

3) The varying output can be fed into the analogue to digital input of a micro-processor programmed to analyse and display the shape and rate of change of the signal and respond to chosen irreg-
-ularities. When two or more signals from two or more transmitters are to be fed into a single

microprocessor input, a standard multiplexing device may be used.

In a further embodiment the minaturised transmitter could be encapsulated and implanted under the skin of the patient in a similar manner to the implantation of pace-makers and other such similar devices.

In a further embodiment the transmitted information using the aforementioned technology could be of a sec--urity nature such as that received from burglar-alarm sensing devices. Such transmitted signals could indicate the presence of an intruder or intruders, or could be fail-safe checking signals.

CLAIMS

1) A transmission apparatus for a telemetry system, comprising means for producing a first signal representing a parameter to be monitored, and means for producing a pulsed radio frequency signal modulated by the first signal, the mark to space ratio of the pulsed signal being low such as 1:5 or less.

2) Apparatus according to claim 1 wherein the mark to space ratio is 1:10 or less.

3) Apparatus according to claim 1 wherein the mark to space ratio is 1:20 or less.

4) Apparatus according to claims 1,2,or 3 further comprising means for producing a second signal representing a further parameter to be monitored, the pulsed radio frequency signal being modulated by the second signal differently to the first signal.

5) Apparatus according to claims 1,2, 3, or 4 wherein the pulse spacing of the pulsed signal is modulated by the first signal.

6) Apparatus according to claim 4 or 5 when dependant on 4, wherein the second signal modulates the height or width of the pulses.

7) Apparatus according to claims 1,2,3,4,5 or 6 wherein the first signal producing means is a medical sensor.

8) Apparatus according to any one of claims 1 to 7, wherein the first signal producing means is an ECG sensor.

9) Apparatus according to claim 4 or anyone of claims

5 to 8 when dependant thereon, wherein the second signal producing means is a medical sensor.

10) Apparatus according to any preceding claim wherein the pulsed signal producing means comprises a pulse generator for producing a pulse train modulated by the first signal, and a radio frequency oscillator for producing an RF carrier modulated by the modul-ated pulse train.

11) Apparatus according to claim 10, wherein the pulse generator comprises a Schmitt trigger oscillator.

12) Apparatus according to claim 7, comprising contain-ing means for containing the apparatus and adapted for attachment to the body of a user.

13) Apparatus according to claim 12, wherein the cont-aining means comprises a first container for cont-aining an electrical power source, and a second container containing at least the pulsed signal producing means.

14) Apparatus according to claim 12, comprising an elec-trical conductor for conducting electrical power from the first container to the second container, and means for selectively breaking the electrical connec-tion between the containers via the conductor.

15) Apparatus according to claim 12,13,or14, further comprising an aerial wire, extending from the cont-aining means, and arranged to be energised by the pulsed signal producing means.

16) Apparatus according to claim 15, further comprising means for attaching the aerial wire to the body of

the user.

17) Apparatus according to claim 14,15,or16, wherein the said electrical conductor is arranged to act as an aerial for the pulsed signal producing means.

18) Apparatus according to claims 12,13,14,15,16,or 17 comprising connecting means providing a separable connection between the first signal producing means and the containing means.

19) A receiver for use with the transmission apparatus of any preceding claim, the receiver comprising;

means for receiving the pulsed radio frequency signal and for producing an intermediate frequ--ency (IF) signal therefrom, and

means for substantially reproducing the modulated pulse train from the IF signal.

20) A receiver according to claim 19 for use with a plurality of transmission apparatus according to any one of claims 1 to 18 transmitting at respective dif--ferent radio frequencies within a preset band, the receiver comprising;

common means for receiving all of the said radio frequencies within said band to produce signals with--in an IF band,

means for separating the resultant IF signals of the respective transmission apparatus, and,

means, one for each transmission apparatus, for reproducing the respective modulated pulse trains.

21) A telemetry system comprising at least one trans-

-mission apparatus according to any one of claims 1 to 18 and a receiver according to claim 19 or 20.

22) A transmission apparatus for a telemetry system comprising;

an input arrangement for receiving a first signal representing a parameter to be monitored, and,

means for producing a pulsed radio frequency signal modulated by the first signal, the mark to space ratio of the pulsed signal being low such as 1;5 or less.

23) A transmission apparatus substantially as herein-before described with reference to;

Figure 3, optionally as modified by Figure 4 and /or Figure 5; or to

Figures 1,2 and 3, optionally as modified by Fig-ure 4 and/or Figure 5.

24) A receiver substantially as hereinbefore described with reference to Figure 6.

25) A telemetry system substantially as hereinbefore described with reference to Figures 3 and 6, opt-ionally as modified by one or more of Figures 1, 2,3,4 and 5.